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# **Development of an Innovative Methodology for Assessing Clinical Activities**

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## **Problem Statement:**

Effective remediation requires that educators assess student variables that are linked to performance deficits. However, extant assessments fall short in providing adequate diagnostic information about *how* medical students apply their knowledge and skills to authentic clinical tasks.<sup>1</sup> Still further, very few instruments are available that specifically examine student motivation and self-regulated learning (SRL) processes as they engage in relevant and authentic clinical activities. Because research has shown that motivation and SRL skills are malleable processes and predictive of success, devising ways to assess these processes could provide a foundation for effective remediation and instructional supports.<sup>2</sup>

## **Approach:**

Based on a process account of SRL,<sup>3</sup> we have refined an established assessment methodology, called SRL microanalysis,<sup>2</sup> and used it to evaluate how students approach (forethought), monitor (performance), and reflect (self-reflection) during clinical activities.<sup>4-5</sup> Specifically, as students work through the history, physical exam, and diagnosis components of a virtual-patient case, we use SRL microanalytic measures to generate qualitative and quantitative data about students' motivation beliefs and SRL processes.

## **Lessons Learned:**

Preliminary results suggest that SRL microanalytic measures not only relate to short- and longer-term outcomes,<sup>4</sup> but they also can be used to document shifts in students' motivational beliefs and SRL during clinical reasoning activities.<sup>5</sup> Further, recent efforts to integrate SRL microanalysis with virtual patients have revealed several challenges and exciting possibilities regarding the use of technology-integrated assessments as part of an existing curriculum.

## **Significance:**

This assessment methodology is innovative because it obtains real-time data on students' motivational beliefs, strategic approaches, and adaptations to performing clinical tasks. Moreover, this approach can be integrated with existing virtual-patient simulations. Taken together, SRL microanalytic data can be used to track student progress on clinical tasks, thereby potentially helping to improve educators' understanding of the types of feedback needed to refine and optimize student motivation and SRL.

## References:

1. Rupp AA, Templin J, Henson RA (2010). *Diagnostic Measurement: Theory, Methods, and Applications*. New York: Guilford Press.
2. Cleary TJ (2011). Emergence of self-regulated learning microanalysis: Historical overview, essential features, and implications for research and practice. In B Zimmerman, D Schunk (Eds.), *Handbook of Self-Regulation of Learning and Performance*. New York: Routledge.
3. Zimmerman BJ (2000). Attaining self-regulation: A social-cognitive perspective. In M Boekaerts, P Pintrich, M Zeidner (Eds.), *Handbook of self-regulation* (pp. 13-39). Orlando, FL: Academic Press.
4. Artino AR, Cleary TJ, Dong T, Hemmer PA, Durning SJ (2014). Exploring clinical reasoning in novices: A self-regulated learning microanalytic assessment approach. *Medical Education*, 48, 280-291.
5. Cleary TJ, Dong T, Artino AR (2015). Examining shifts in medical students' microanalytic motivation beliefs and regulatory processes during a diagnostic reasoning task. *Advances in Health Sciences Education*. doi: 10.1007/s10459-014-9549-x

Running Head: SELF-REGULATED LEARNING MICROANALYSIS

Assessing Contextualized, Dynamic Processes:  
The Benefits and Limitations of Self-Regulated Learning Microanalysis

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## Assessing Contextualized, Dynamic Processes:

### The Benefits and Limitations of Self-Regulated Learning Microanalysis

Scholars and practitioners across a diverse array of specialties and disciplines have long been interested in understanding why individuals, who despite possessing adequate intellectual and cognitive abilities and being provided with sufficient encouragement and feedback, display inconsistent performance. The answer to this question is certainly complex and necessitates consideration of a range of non-intellectual variables, including personality characteristics, quality of instruction, and individual beliefs, attitudes, and strategic skills. Over the past few decades, researchers across different domains have devoted much attention to examining the role that self-regulated learning (SRL) processes, such as planning, strategic behaviors, and reflection, have on academic learning (Boekaerts, Pintrich, & Zeidner, 2000; Zimmerman & Schunk, 2011), mental health and addictive behaviors (Baumeister & Vohs, 2007), chronic disease management (Clark, 2013), and optimal performance in sports and other leisure activities (Cleary, Zimmerman, & Keating, 2006; McPherson, 2011). Despite the relatively robust literature linking SRL skills with success, an emergent issue in the SRL literature involves the extent to which different assessment methodologies are capable of capturing unique aspects of how individuals regulate during authentic tasks and activities within a given domain.

In this paper, we provide an overview of one type of assessment methodology, called SRL microanalysis, which has been used to study SRL processes across a variety of different tasks and activities. We detail the theoretical foundation of this assessment methodology, the core assumptions and characteristics, as well as its primary strengths and weaknesses. We also provide examples of how this methodology has been used by researchers to examine the quality of individuals' regulatory processes during academic and non-academic tasks, with primary

emphasis placed on a recent application to a diagnostic reasoning task in a medical education context. Before we discuss SRL microanalysis, however, we first describe SRL in greater detail and present a theoretical model that serves as the foundation for SRL microanalytic procedures.

### **Overview of SRL as a Contextualized Dynamic Process**

SRL has been described as a process through which individuals exert control over their behaviors, cognitions or affect, and the environment as they engage in goal-directed activities (Boekaerts et al., 2000; Schunk, 2012). Although we recognize that there are several different theories of SRL and that researchers across various disciplines target constructs related to SRL, including self-directed learning, self-management, executive functions, and reflective practice (see Cleary, Durning, Gruppen, Hemmer, & Artino, 2013 for an overview), we focus primarily on social-cognitive theoretical principles and frameworks (Bandura, 1986; Zimmerman, 2000). On a general level, social-cognitive theory emphasizes a proactive, agentic perspective of human functioning whereby individuals seek out appropriate models from which to learn and use their regulatory capabilities such as self-observation, self-judgments, and self-reactions, to manage and control their thoughts, behaviors and environment. Social-cognitive theorists emphasize that learning and behaviors are largely contextualized and thus what an individual thinks and does will often vary and change across contexts.

Building from this initial social-cognitive framework, Zimmerman (2000) developed a model of SRL that emphasized the inter-relatedness among SRL processes, specifically detailing how the different sub-processes operate as a type of cyclical feedback loop. From this perspective, SRL has been defined as self-generated thoughts, actions, and feelings that are intentionally and proactively generated and used by learners to attain personal goals (Zimmerman, 2000). These regulatory processes are subsumed within a three-phase cyclical

feedback loop, consisting of three general phases: forethought (before engaging in a task), performance (during task engagement), and self-reflection (following performance on the task). Forethought phase processes include establishing *personal goals* and *strategic plans* in relation to performing specific tasks. Goal setting involves deciding upon specific outcomes of learning or performance while strategic planning refers to the selection of specific strategies that will facilitate the acquisition or display of skill (Zimmerman, 2000).

As sophisticated self-regulated learners attempt to perform a task or activity in a given situation (i.e., during the performance phase of the model), they will often attempt to exert *self-control* over personal processes, such as behavior, affect, and cognition (e.g., attention-focusing, self-instruction statements) as well as the environment in order to optimize task performance. Individuals who are highly regulated also tend to be interested in gathering data about their skills and performance progress and thus will often proactively monitor and record performance outcome as well as the types of actions and thoughts they exhibit during learning (i.e., self-observation). Collectively, these strategic and monitoring-related behaviors are purposefully selected and implemented in order to maximize the likelihood of successfully performing a task and to gather relevant data that can be used during the third phase of the model, self-reflection.

During the self-reflection aspect of the feedback loop, self-regulated learners will often make a few critical self-judgments about their performance, such as whether they attained their goals (i.e., *self-evaluation*) and the reasons underlying their performance (i.e., *attribution*). These judgments will, in turn, impact the conclusions or inferences that learners make about what they need to do to improve future performance on a particular task (*adaptive inferences*). An iteration of the cyclical feedback loop is complete when self-reflection phase processes impact students' forethought processes prior to a subsequent learning or performance activity. This process-

oriented, dynamic feedback model has served as the foundation from which SRL microanalytic methodology has evolved.

### **Measurement of SRL**

Historically, a variety of assessment approaches have been used to study SRL behaviors and processes. The most common method involves the use of questionnaires (Cleary, 2009; Dinsmore et al., 2010), whereby individuals are asked to read a series of statements about their regulatory behaviors and/or beliefs and attitudes and then retrospectively rate to what extent those statements reflect their own beliefs and behaviors in a given context. Other SRL assessments include teacher or parent rating scales (Cleary & Callan, in press), structured interviews (Zimmerman & Martinez Pons, 1986), behavioral traces (Winne & Perry, 2000), think-aloud protocols (Azevedo, 2005), direct observations (Perry, 1998), and SRL microanalytic protocols (Artino, Cleary, Dong, Hemmer, & Durning, 2014; Cleary, Callan & Zimmerman, 2012; Cleary & Zimmerman, 2001). Although each of these assessment tools has a unique profile of strengths and weaknesses, an emergent trend in the SRL literature has been to utilize measures that have the following characteristics: (a) highly context- and task-specific, (b) administered in real time during authentic tasks, and (c) exhibit strong psychometric characteristics. Examples of these types of on-line or *event* methods include think alouds, direct observations, behavioral traces, and SRL microanalytic protocols. Unlike self-report questionnaires or rating scales, event measures are beneficial because they are not adversely influenced by memory distortions or errors due to retrospective responding. Further, because they are highly contextualized and are administered in relation to specific tasks and activities, the data that are generated have the potential to be much more meaningful for practitioners. In this

paper, we devote the majority of our attention to one type of event measure, SRL microanalytic protocols.

### **Overview of SRL microanalytic methodology**

SRL microanalysis evolved from social-cognitive theory in general and from Zimmerman's three-phase cyclical feedback model more specifically. This approach, which traditionally has utilized a context-specific, structured interview protocol, adheres to a "strategic, coordinated plan of administering context-specific questions targeting multiple cyclical phase sub-processes as students engage in authentic activities" (Cleary et al., 2012, p. 4). This assessment approach includes the following essential features: (a) individualizing administration, (b) using theoretically-grounded, highly contextualized questions, (c) linking regulatory questions to the phase dimensions of the three-phase SRL model, and (d) coding and scoring responses. In this paper, we focus primarily on the nature of microanalytic questions and how they are administered during the interview session.

**Nature of microanalytic questions.** All microanalytic questions are developed based on theoretical definitions of the phase-specific SRL sub-processes. Typically, researchers have evaluated several self-regulatory processes (e.g., goal setting, strategic planning, self-efficacy, attributions) within and across the three SRL cyclical phases. Although the microanalytic questions can either be open- or closed-ended, the majority of questions utilize a free-response format that enables individuals to provide elaborated responses (Cleary et al., 2012; Cleary & Zimmerman, 2001). From our perspective, a free-response format is ideal because, unlike self-report questionnaires, it does not provide the "answers" to which individuals simply have to make a rating or judgment. Rather, respondents are required to provide their thoughts, beliefs, and reactions in a particular moment in time as they complete a specific task. Given the highly

contextualized and task-focused nature of this approach, single questions are typically used to target each of the specific SRL sub-processes subsumed within the three-phase loop. There is a strong literature base showing that these single-item, contextualized questions have high levels of inter-rater reliability, can adequately distinguish between high and low achievers, and can account for unique variance in future performance outcomes (Artino et al., 2014; Cleary et al., 2012; DiBenedetto & Zimmerman, 2013; Kitsantas & Zimmerman, 2002).

**Linking microanalysis to temporal task dimensions.** Each of the SRL microanalytic questions are purposefully developed and administered to examine individuals' SRL processes as they engage in authentic tasks and activities (Cleary et al., 2012). To date, these protocols have been developed and customized to a variety of domains, including athletic skills (e.g., free-throw shooting, volleyball serving; Cleary & Zimmerman, 2001; Kitsantas & Zimmerman, 2002), academic tasks (e.g., reading, studying, test preparation; Cleary, Callan, Peterson, & Adams, 2011; DiBenedetto & Zimmerman, 2013; Zimmerman & Kitsantas, 1999), and clinical activities in medicine (e.g., venepuncture, diagnostic reasoning; Artino et al., 2014; Cleary & Sandars, 2011; see Table 1 for an abbreviated list of studies using microanalysis across various tasks).

Regardless of the specific task around which one seeks to embed the SRL microanalytic protocol, it is important that the task has a well-defined and clear beginning, middle and end. Clarifying the temporal dimensions of a task is essential because it allows one to directly embed the forethought, performance, and reflection questions relative to these specific task dimensions. In essence, the microanalytic protocol is structured so that the forethought phase questions are administered *before* one begins the task, performance phase questions are administered *during* the task, and reflection phase questions are administered *after* performance. Establishing direct links between SRL theory, the assessment process, and the nature of a task allows researchers or

practitioners to make theoretically grounded interpretations about how SRL process are initiated, sustained, or modified during a relevant task.

### **Advantages and limitations of SRL microanalysis**

In school contexts, legal mandates and best practices require that diagnosticians or school psychologists conduct comprehensive evaluations that involve using a variety of assessment tools (e.g., standardized tests, questionnaires, interviews) administered to different sources (e.g., students, teachers) in order to gather data about different areas of functioning (e.g., intellectual, academic) for a student (Cleary et al., 2012). The basic assumption of this practice is that a single measure can rarely capture all the components of a construct, particularly when a construct, like self-regulation, is multi-dimensional and dynamic in nature. Further, despite many assessment tools sharing specific characteristics or features, most have a unique set of strengths and weaknesses that make them desirable under certain conditions but less effective in other contexts. Although the use of a multi-dimensional assessment approach is a goal of SRL measurement (Butler, 2011; Cleary & Platten, 2013), in this section we underscore the primary advantages and limitation of SRL microanalysis, particularly when viewed in relation to other types of SRL measures.

**Strengths and advantages.** Unlike many types of SRL measures that rely on retrospective, aggregated ratings of items that are often devoid of focused situational referents, such as self-report questionnaires or teacher ratings, SRL microanalytic protocols provide a more contextually rich, in-the-moment profile of SRL processes that relate to particular tasks that are deemed to be important or relevant in a given domain. From a diagnostic point of view, because microanalytic protocols are highly contextualized and task-specific, the data that they generate have strong potential to help educators and practitioners identify deficient regulatory processes

and to use those data as a platform from which to intervene with students who are struggling (Cleary & Platten 2013; Peters-Burton, 2013).

As indicated previously, SRL microanalysis is a type of event measure because it targets regulatory skills as they occur during an event or specific task. In this respect, they are similar to other measures such as behavioral traces, observations, and think alouds. However, SRL microanalytic measures are distinct from behavioral traces and observations because microanalytic protocols are designed to measure covert SRL processes including students' self-efficacy perceptions, goals, plans, and reflective judgments, such as attributions. Given that social-cognitive models of SRL assume that thoughts, beliefs, and metacognition directly impact behaviors, it is important to gather information about these covert processes to more clearly understand the nature of the behaviors that may be observed.

Think-aloud protocols and SRL microanalysis procedures are similar in that they involve gathering information about an individual's strategic thoughts and beliefs as he or she performs an activity. They are distinct, however, in the procedures used to elicit the person's thoughts and verbalizations. Think alouds entail having individuals talk aloud as they perform a task, without the examiner providing any prompts or asking any questions. In contrast, microanalytic measures purposefully and strategically present questions to individuals about their SRL processes at different points during task completion. Although each of these two approaches is beneficial and important, the advantage of SRL microanalytic protocols is that they can capture specific types of information that can be used to draw conclusions, specifically about how individuals prepare, self-direct, and reflect on task performance.

Another strength of microanalytic methodology is the emerging evidence that this type of assessment possesses strong psychometric properties, as evidenced by inter-rater reliability,

differential validity, convergent validity, and predictive validity (Cleary et al., 2012).

Furthermore, there is emerging evidence that SRL microanalytic protocols are more predictive of performance outcomes than other forms of SRL assessment, such as self-report questionnaires (Callan & Cleary, 2014; Cleary et al., 2011).

**Weaknesses and limitations.** As is the case with most assessment approaches, SRL microanalytic protocols do possess some limitations. For example, SRL microanalytic questions are highly contextualized and target individuals' regulatory processes during a single moment in time as they perform a particular task. Although this feature is desirable from a contextualist point of view, the data gathered from this assessment approach may not generalize to other contexts or situations. Thus, this approach was developed to be primarily concerned with addressing the question, "How is the person regulating their behaviors during this particular event or activity?" rather than, "How does this person regulate their behaviors in general?" Another weakness is that because SRL microanalytic protocols entail an examiner asking questions of a respondent during a task, one can question whether the responses are true accounts of what individuals would have been thinking if the microanalytic probe or prompt had not been administered (i.e., reactivity effects).

A third potential drawback of microanalytic protocols is that because they historically have been primarily concerned with measuring covert aspects of SRL, such as thought processes and metacognitive judgments and reactions, they have not typically been used to directly measure overt indicators of SRL, such as help-seeking behavior and actual use of strategies. From our perspective, however, the term SRL microanalysis does not restrict assessment to only the cognitive and metacognitive dimensions. In fact, researchers have used various assessment approaches that track micro-level behaviors, such as mother-infant interactions (Peck, 2003),

interactions among multiple family subsystems (Gordon & Feldman, 2008), and therapist-client interactions (Stiles et al., 2006). Although not systematically examined at this point, it is critical for microanalytic researchers to begin to examine how traditional microanalytic questions can be supplemented with microanalytic, behavioral indicators of those covert processes.

Finally, although recent attempts have been made to apply SRL microanalysis to examine cognitive activities, such as clinical reasoning with medical students, it is important to underscore that microanalytic protocols are not well-suited to examine automatic or unconscious processes that may occur during reasoning activities, particularly in those who are expert clinicians (Norman, 2005).

### **Applications of SRL microanalysis**

As alluded to previously, SRL microanalytic protocols have been extended and applied to a diverse array of tasks (see Table 1). In addition to the broad applicability of this assessment paradigm, researchers have used this approach for a variety of different purposes and objectives, including identifying group differences (Cleary & Zimmerman, 2001; DiBenedetto & Zimmerman, 2013), predicting performance outcomes (Artino et al., 2014; Kitsantas & Zimmerman, 2002), evaluating the effects of interventions (Cleary et al., 2006), and most recently, exploring shifts in students' regulatory processes during a task (Cleary, Dong, & Artino, 2014). Collectively, various ex post facto studies have shown that experts or high achievers display more adaptive forms of SRL, such as setting more specific goals and exhibiting adaptive, strategic forms of planning and self-reflection. For example, Cleary & Zimmerman (2001) showed that expert basketball free-throw shooters in high school displayed more specific goals and higher quality strategic plans and attributions than their non-expert teammates and novices. There is also emerging data that SRL processes not only predict proximal and task-

specific outcomes but also long-term performance indicators. For example, whereas Kitsantas and Zimmerman (2002) showed that microanalytic responses of volleyball players predicted approximately 90% of the variance in the target task of volleyball serving, Artino and colleagues (2014) found that a strategic planning microanalytic question accounted for approximately 8-14% of the variance in important medical school performance indicators (e.g., licensing examination scores) after controlling for reasoning ability and prior achievement.

Other lines of research have examined changes in individuals' SRL microanalytic processes following an intervention. In an experimental study with college-aged students, Cleary et al. (2006) showed that novice basketball players who received multiple-phase training in SRL processes (i.e., training in forethought, performance, and/or self-reflection) as they practiced their free-throw shooting, exhibited more adaptive attributions and adaptive inferences following missed free-throws and an overall stronger shooting skill than those who did not receive such training. In the following section, we review a recent study that used SRL microanalysis to examine shifts in students' SRL processes during a diagnostic reasoning activity (Cleary, Dong, & Artino, 2014). Our primary objective is to illustrate how microanalysis was employed to investigate SRL processes during multiple iterations of this task.

**Illustration of the SRL microanalytic process.** Cleary et al. (2014) was one of the first studies to employ microanalytic methodology to examine how medical students' self-efficacy and quality of strategic thinking (i.e., planning, metacognitive monitoring) shifted as they completed multiple iterations of a diagnostic reasoning activity. In this study, 71 second-year medical students were asked to participate in a 25-30 minute diagnostic reasoning session. During this session, read a one-page paper case depicting diabetes mellitus and were afforded the opportunity to use a post-encounter form (PEF) as a guide for developing and generating an

accurate diagnosis. After submitting their final diagnosis, the students were provided simple corrective feedback: “Sorry, your most likely diagnosis is incorrect.” The participants were then given the opportunity to complete another PEF as they engaged in the second iteration of the same clinical reasoning activity. Following their second attempt at generating a most likely diagnosis, the students were again read a similar corrective feedback statement. It should be noted that the diagnostic reasoning task was intentionally developed to be challenging because the authors were interested in examining students’ reactions following feedback about their failure to arrive at a correct diagnosis.

*Nature of microanalytic questions.* To evaluate shifts in students’ self-efficacy beliefs and SRL processes during the multiple iteration activity, the authors embedded three microanalytic questions into the diagnostic reasoning task: self-efficacy, strategic planning, and metacognitive monitoring. The single item *self-efficacy* measure was developed using guidelines outlined by Bandura (2006) and examined the participants’ confidence about their ability to generate the correct diagnosis (see Figure 1). A single-item measure of strategic planning was used to assess participant plans for approaching the diagnostic reasoning task. A variation of an existing planning question was used (Cleary et al., 2012). Participants were asked, “What do you think you need to do to perform well on this activity?” Participant responses to the strategic planning question were coded into one of six categories: *task-specific process*, *task-general process*, *self-control*, *non-task strategy*, *do not know/none*, and *other*. Finally, the metacognitive monitoring question examined the extent to which the participants focused on strategic processes during each of the two iterations of the clinical reasoning task. Across both iterations, the participants were stopped after they wrote down their first differential diagnosis on the PEF and asked, “As you have been going through this process, what has been the primary thing you have been

thinking about or focusing on?” If the participants provided a response, they were asked, “Is there anything else you have been focusing on?” Student responses were coded into one of seven categories. Four categories were similar to the strategic planning measure, *task-specific process*, *task-general process*, *self-control*, and *other*. Three additional categories were added to this coding scheme, *outcome*, *perceived ability* and *task difficulty*. Using similar coding procedures employed for the strategic planning measure, an inter-rater level of agreement of 88% was attained for both strategic planning and metacognitive monitoring questions.

Given that the strategic planning and metacognitive monitoring measures used a free-response format, and because participants were permitted to provide multiple, codeable responses to each question, the authors transformed the categorical responses to a metric scale to facilitate interpretation. The scoring system was designed to capture the strategic quality of the participants’ regulatory processes during the specific task, with greatest weight given to responses that reflected one or more of the five strategic steps identified for the diagnostic reasoning task. This scoring system was an adaptation of a prior scoring scheme and was developed based on theory, prior research, and expert consensus (Artino et al., 2014; Cleary et al., 2011).

*Link between measures and diagnostic reasoning task.* Consistent with the guidelines put forth by Cleary (2011), there was a direct link between the temporal dimensions of the diagnostic reasoning task and the administration sequence of microanalytic questions (see Figure 1). For example, the microanalytic questions were purposefully administered to parallel the temporal dimensions of the task, such that self-efficacy and strategic planning (i.e., forethought phase processes) were administered *prior* to attempting each of the two iterations. These two forethought phase processes were assessed at three points: prior to initiating the task, before

beginning the second iteration of the task, and prior to a prospective third iteration. Given that the authors were also interested in gathering information about the types of thoughts that students were exhibiting during both iterations of the diagnostic reasoning task, they administered a metacognitive monitoring probe (which is a performance phase process) *during* both task iterations.

*Results and implications.* Repeated measure analyses were used to examine the presence of linear or quadratic trends across three time points (before the first iteration, before the second iteration, and before a prospective third iteration) for the self-efficacy and strategic planning measures (see Figure 1). Separate paired t-tests were used to examine shifts from Time 1 to Time 2 and from Time 2 to Time 3. Finally, a simple paired t-test was used to examine changes in the metacognitive monitoring question, given that only two data points were collected. See Table 2 for an overview of means and standard deviations of measure across time points.

The key result was that although the participants' exhibited, on average, a moderate levels of self-efficacy and focused on the strategic qualities of the diagnostic reasoning task at the beginning of the sessions, they exhibited statistically significant declines in both the confidence levels (*self-efficacy*;  $F(1,67) = 114.37, p < .001, \eta_p = .631$ ) and the quality of their strategic thinking (*strategic planning*;  $F(1,70) = 5.32, p = .024$ , symbol  $\eta_p = .07$ ; *metacognitive monitoring*,  $t(70) = 2.91, p = .005, d = 0.49$ ) during the 20-30 minute activity. Qualitatively, the results showed that although approximately two thirds of the participants (65%) focused on the strategic process typically used in diagnostic reasoning (e.g., identify symptoms, integration etc.) at the beginning of the task, less than 25% of participants sustained this focus on strategic thinking at the end of the task. The declines in strategic thinking paralleled the large drops in participant self-efficacy during the task.

From our perspective, the most striking aspect of this study entailed the immediacy and size of the drop in both self-efficacy and quality of strategic thinking over a relatively short time period. These findings are particularly relevant to medical educators because clinical reasoning activities are a critical focus in medical education and because the practice session used in this study represented a close approximation of a typical practice opportunity provided to students enrolled in a medical education course at the target school. It is important for medical educators to be cognizant of how quickly student motivation and thinking can change during a single task and how providing simple, negative task feedback can push some students toward a maladaptive path of self-doubt and potential withdrawal or disengagement (Bandura, 1997; Hattie & Timperley, 2007; Pajares & Urdan, 2006).

### **Where does SRL microanalysis go from here?**

One of the original purposes of developing SRL microanalytic protocols was to provide diagnostic information that practitioners, clinicians, or educators can use to provide process or SRL-type feedback to students about how they approach and go about completing important tasks (Cleary et al., 2012). At this point, although a few researchers have begun to provide qualitative and anecdotal evidence for the viability of using SRL microanalytic data for this purpose (Cleary & Platten, 2013; Peters-Burton, 2013), there is a need to more systematically examine this issue in a more comprehensive fashion. In particular, it is important to consider how professional educators and trainers, who may not be experts in SRL terminology and principles, can use this approach in their work and interactions with students.

We also envision integrating SRL microanalytic protocols with behavioral observations and behavioral traces of SRL and motivated behaviors. Although there is ample evidence to support the use of SRL microanalytic protocols to differentiate achievement groups across

empirically supported constructs (e.g., goal setting, planning etc.), greater attention should be devoted to exploring how SRL microanalytic data converge with behavioral indicators of SRL and to explore the reciprocal nature of the relation between these two sources of data.

In this paper, we provided an overview of SRL microanalysis, detailing the theoretical foundation of this assessment methodology, the core assumptions and characteristics, and its primary strengths and weaknesses. We also provided examples of how this methodology has been used by researchers to examine the quality of individuals' regulatory processes during academic and non-academic tasks, including specific emphasis on a recent application to diagnostic reasoning tasks in medical education. Although much more research is clearly needed to examine the utility and psychometric quality of this assessment approach, particularly as it relates to different populations and contexts, we believe SRL microanalysis has the potential to improve the quality with which educators provide instruction, feedback, and remediation to students in various educational contexts.

## References

- Artino, A. R., Cleary, T. J., Dong, T., Hemmer, P. A., & Durning, S. J. (2014). Exploring clinical reasoning in novices: A self-regulated learning microanalytic approach. *Medical Education, 48*, 280-291.
- Azevedo, R. (2005). Using hypermedia as a metacognitive tool for enhancing student learning? The role of self-regulated learning. *Educational Psychologist, 40*, 199-209.
- Bandura, A. (1986). *Social foundations of thought and action: A social cognitive theory*. Englewood Cliffs, NJ: Prentice Hall.
- Bandura, A. (1997). *Self-efficacy: The exercise of control*. New York: W.H. Freeman.
- Baumeister, R. F., & Vohs, K. D. (Eds.). (2004). *Handbook of self-regulation: Theory, research, and applications*. New York: Guilford Press.
- Boekaerts, M., Pintrich, P. R., & Zeidner, M. (Eds.). (2000). *Handbook of self-regulation*. San Diego, CA: Academic Press.
- Butler, D. L. 2011. Investigating self-regulated learning using in-depth case studies. In B. J. Zimmerman, & D. H. Schunk (Eds.), *Handbook of Self-Regulation of Learning and Performance* (pp. 346-360). New York: Routledge.
- Cleary, T. J. (2009). School-based motivation and self-regulation assessments: An examination of school psychologist beliefs and practices. *Journal of Applied School Psychology, 25*, 71-94.
- Cleary, T. J., & Callan, G. L. (in press). Student self-regulated learning in an urban high school: Correspondence and predictive validity of teacher ratings and student self-reports. *Journal of Psychoeducational Assessment*.

- Cleary, T. J., Callan, G., & Zimmerman, B. J. (2012). Assessing self-regulation as a cyclical, context-specific phenomenon: Overview and analysis of SRL microanalytic protocols [Special Issue]. *Education Research International*. doi:10.1155/2012/428639.
- Cleary, T.J., Callan, G., Peterson, J., & Adams, T. (2011, April). *Using SRL Microanalysis in an academic context: Conceptual and empirical advantages*. Paper presented at the annual conference for the American Educational Research Association, New Orleans, LA.
- Cleary, T. J., Dong, T., & Artino, A. R. (2014). Examining shifts in students microanalytic motivation beliefs and regulatory processes during a diagnostic reasoning task. Manuscript submitted for publication.
- Cleary, T. J., Durning, S., Gruppen, L., Hemmer, P., & Artino, A. (2013). Self-regulated learning in medical education. In K. Walsh (Ed.), *Oxford Textbook of Medical Education* (pp.465-477). Oxford, United Kingdom: Oxford University Press.
- Cleary, T. J., & Platten, P. (2013). Examining the correspondence between self-regulated learning and academic achievement: A case study analysis [Special Issue]. *Educational Research International*. doi: 10.1155/2013/272560
- Cleary, T. J., & Sandars, J. (2011). *Self-regulatory skills and clinical performance: a pilot study*. *Medical Teacher*, 33, e368-e374.
- Cleary, T. J., & Zimmerman, B. J. (2001). Self-regulation differences during athletic practice by experts, non-experts, and novices. *Journal of Applied Sport Psychology*, 13, 61-82.

- Cleary, T. J., Zimmerman, B. J., & Keating, T. (2006). Training physical education students to self-regulate during basketball free-throw practice. *Research Quarterly for Exercise and Sport*, 77, 251-262.
- DiBendetto, M. K., & Zimmerman, B. J. (2013). Construct and prective validity of microanalytic measures of students' self-regulation of science learning. *Learning and Individual Differences*, 26, 30-41.
- Dinsmore, D. L., Alexander, P. A., & Loughlin, S. M. (2008). Focusing the conceptual lens on metacognition, self-regulation, and self-regulated learning. [Special Issue on Metacognition, self-regulation, and self-regulated learning: Historical roots and contemporary manifestations]. *Educational Psychology Review*, 20, 391-409.
- Hattie, J., & Timperley, H. (2007). The power of feedback. *Review of Educational Research*, 77, 81-112.
- Gordon, I., & Feldman, R. (2008) Synchrony in the triad: A micro level process model of co-parenting and parent-child interactions. *Family Processes*, 47, 465-479.  
[doi:10.1111/j.1545-5300.2008.00266.x](https://doi.org/10.1111/j.1545-5300.2008.00266.x)
- Kitsantas, A., & Zimmerman, B. J. (2002). Comparing self-regulatory processes among novice, non-expert, and expert volleyball players: A microanalytic study. *Journal of Applied Sport Psychology*, 14, 91-105.
- McPherson, G. E., & Renwick, J. M. (2011). Self-regulation and mastery of musical skills. In B. J. Zimmerman, & D. H. Schunk (Eds.), *Handbook of self-regulation of learning and performance* (pp. 234-250). New York: Routledge.
- Norman G. (2005). Research in clinical reasoning: Past history and current trends. *Medical Education*, 39, 418-427.

- Pajares, F., & Urdan, T. (Eds.). (2006) *Self-efficacy beliefs of adolescents*. Greenwich, CT: Information Age Publishing.
- Peck, S. D. (2003). Measuring sensitivity moment-by-moment: A microanalytic look at the transmission of attachment. *Attachment & Human Development*, 5(1), 38-63. doi: 10.1080/1461673031000078661
- Peters-Burton E. E. (2013). Student work products as a teaching tool for nature of science pedagogical knowledge: A professional development project with in-service secondary science teachers. *Teaching and Teacher Education*, 29, 156-166. DOI: 10.1016/j.tate.2012.09.005
- Schunk, D. H. (2012). *Learning theories: An educational perspective* (6<sup>th</sup> ed.). Boston, MA: Pearson.
- Stiles, W. B., Barkham, M., Twigg, E., et al (2006) Effectiveness of cognitive-behavioural, person-centered, and psychodynamic therapies as practiced in UK National Health Service settings. *Psychological Medicine*, 36, 555 –566.  
[doi:10.1017/S0033291706007136](https://doi.org/10.1017/S0033291706007136)
- Winne, P. H., & Perry, N. E. (2000). Measuring self-regulated learning. In M. Boekaerts, P. Pintrich, & M. Zeidner (Eds.), *Handbook of Self-Regulation* (pp. 532-566). Orlando, FL: Academic Press.
- Zimmerman, B. J. (2000). Attaining self-regulation: A social cognitive perspective. In M. Boekaerts, P. R. Pintrich, & M. Zeidner (Eds.), *Handbook of self-regulation* (pp. 13-39). San Diego, CA: Academic Press.
- Zimmerman, B. J., & Kitsantas, A. (1999). Acquiring writing revision skill: Shifting from process to outcome self-regulatory goals. *Journal of Educational Psychology*, 91, 1-10.

Zimmerman, B.J., & Martinez-Pons, M. (1986). Development of a structured interview for assessing student use of self-regulated learning strategies. *American Educational Research Journal*, 23, 614-628.

Zimmerman, B., & Schunk, D. (Eds.) (2011). *Handbook of self-regulation of learning and performance*. New York: Routledge.

Table 1

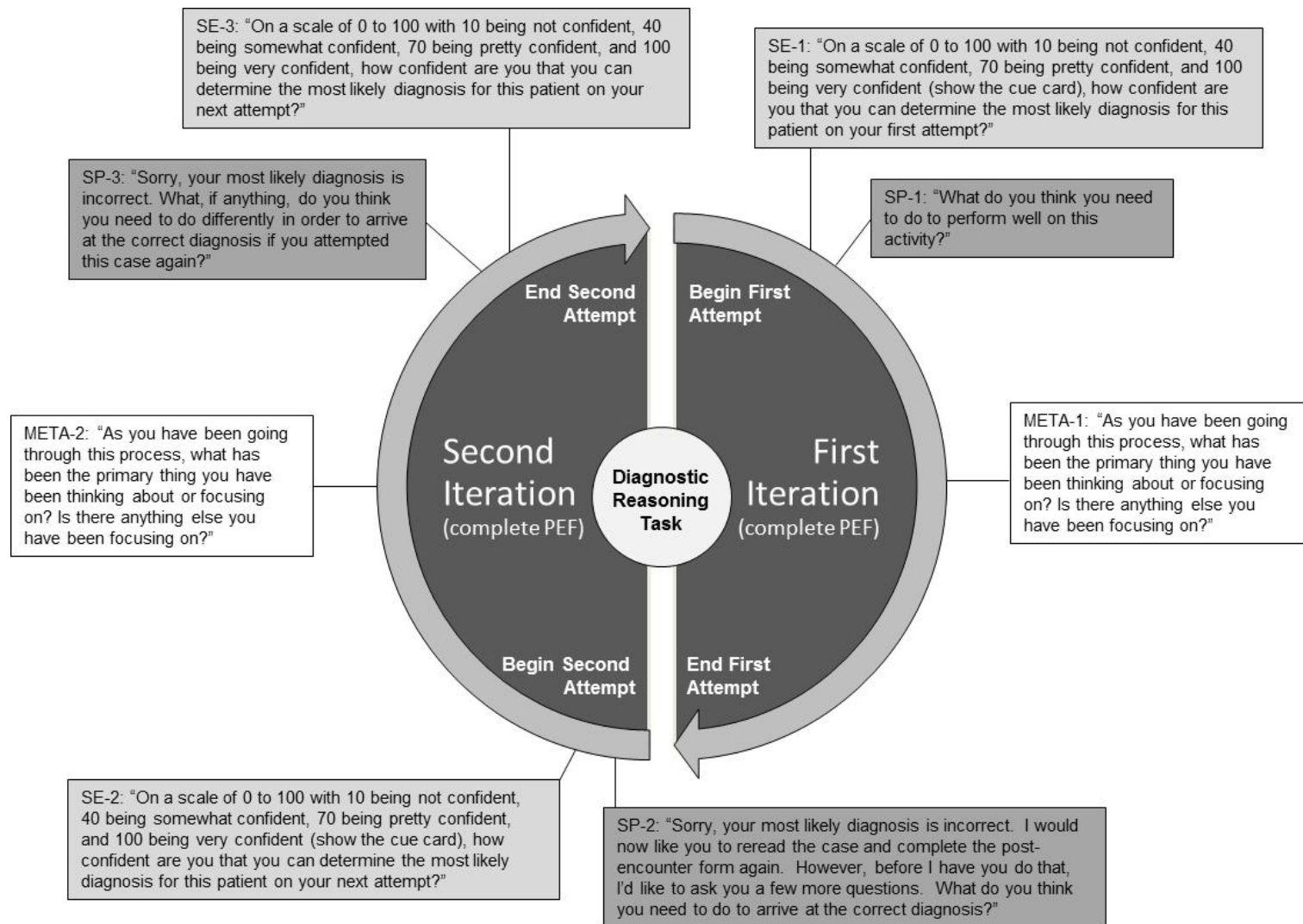
Selected examples of SRL Microanalytic Studies Across Tasks and Domains

Type of Task	Study	Forethought	Performance	Self-reflection
Athletic tasks				
Dart throwing	Kitsantas, Zimmerman, & Cleary, (2000)	-	-	- Attribution
Basketball shooting	Cleary & Zimmerman (2001)	- Goal setting - Strategy choice	-	- Attribution - Adaptive infer.
Volley Ball serving	Kitsantas & Zimmerman (2002)	- Goal setting - Planning - Strategic plan	- Strategy use - Self-monitor	- Self-evaluation - Attribution
Academic tasks				
Reading and studying in science	Dibenedetto & Zimmerman (2010)	- Goal setting - Strategic plan	- Metacognitive monitoring - Strategy use	- Self-evaluation - Attribution - Adaptive infer. - Satisfaction
Test reflection	Cleary, Callan, Peterson, & Adams (2011)	- Strategic plan	-	- Self-evaluation - Attribution - Adaptive infer.
Math problem-solving	Callan & Cleary (2014)	- Goal setting - Strategic Plan	- Strategy use - Metacognitive monitoring	- Attributions - Adaptive infer.
Clinical tasks				
Venepuncture	Cleary and Sandars (2011)	- Goal setting - Strategic plan	- Metacognitive monitoring	- Self-evaluation (forced choice)
Diagnostic reasoning task	Artino et al (2014)	- Goal setting - Strategic plan	- Metacognitive monitoring	
Diagnostic reasoning	Cleary et al., (2014)	- Strategic plan	- Metacognitive monitoring	-

Table 2. Means and standard deviations for all dependent measures

Timing of assessment	Self-efficacy		Strategic planning		Metacognitive monitoring	
	Mean	<i>SD</i>	Mean	<i>SD</i>	Mean	<i>SD</i>
Time 1	53.73	18.51	.86	1.74	3.08	2.05
Time 2	44.30	18.43	1.15	1.74	1.94	2.57
Time 3	27.13	17.48	.10	1.87	NA	NA

*Note.* For the self-efficacy and planning measures, Time 1 = before first iteration; Time 2 = before second iteration; and Time 3 = before prospective third iteration. The metacognitive monitoring measure was only administered twice during the task, Time 1 = during first iteration whereas Time 2 = during second iteration. NA = Not applicable.



*Figure 1.* To evaluate shifts in students' SRL processes and self-efficacy beliefs during the multiple iteration activity, an SRL microanalytic interview was administered to the participants at different points during the task. The form and sequence of each interview question is provided here.